Mutagenicity and Toxicity of Biomass Smoke are Dependent on Fuel Type and Combustion Conditions

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There is growing concern about potential health impacts from exposure to wildland fire smoke, but little is known about the relative toxicity originating from different fuel types and combustion conditions. Here we tested five different types of biomass fuels (red oak, peat, pine needles, pine, and eucalyptus) at two different combustion conditions (flaming and smoldering) in a novel combustion and smoke-collection system. Specifically we were able to sustain stable flaming and smoldering conditions for up to 60 min, while cryogenically collecting particulate and semi-volatile phases of the smoke emissions in multi-stage impingers (-10°C followed by -50°C, and ending in -70°C). Biomass smoke condensates were extracted and assessed for mutagenicity in *Salmonella* strains TA100 and TA98 +/-S9, as well as lung toxicity in mice via oropharyngeal aspiration (100 µg per mouse). Carbon dioxide, carbon monoxide (CO), and particulate matter (PM) concentrations monitored continuously during the combustion process were used to calculate modified combustion efficiency (MCE) and emission factors (EFs). We found that the MCE of all the biomass fuels ranged from 63% to 83% during smoldering conditions and 97% to 99% during flaming conditions. In addition, all the biomass fuel EF for CO ranged from 158 g/kg to 299 g/kg for smoldering but only 16 g/kg to 29 g/kg for flaming. The EF for PM ranged from 55 g/kg to 174 g/kg for smoldering but only 0.6 g/kg to 1.6 g/kg for flaming. A preliminary assessment of the mutagenic potency of the biomass smoke showed that flaming emissions from eucalyptus were up to ~19 times more mutagenic than smoldering emissions on an equal-mass smoke-exposure basis (revertants/µg PM). However, on an equal-mass fuel-consumption basis, the mutagenicity-emission factor (revertants/megajoule of thermal energy consumed) of smoldering emissions of red oak was up to ~107 times greater than that of flaming emissions. Most mutagenicity-emission factors were greater in strain TA100 +S9 than –S9, indicating that the mutagenicity was associated with polycyclic aromatic hydrocarbons. Similarly, on an equal-mass smoke-exposure basis, peat and eucalyptus flaming emissions elicited significant inflammation (neutrophils) in mouse lungs 24 h post-exposure. However, smoldering emissions caused greater lung inflammation than flaming emissions on an equal-mass fuel-consumption basis. Our findings demonstrate that the (1) type of fuel and combustion conditions can alter dramatically the emission characteristics, mutagenicity, and lung toxicity; (2) present system can be useful for health-risk assessment from inhalation exposure to various wildfire smoke; and (3) health impacts of wildfire smoke can be assessed on an equal-mass PM-exposure basis or an equal-mass fuel-consumption basis. [This study was funded through the Joint Fire Science Program (JFSP) project # 14-1-04-16. This abstract does not represent official USEPA policy.]